Cu Bel.7 Co Ni

Common names: Beryllium Copper
Beryllium Bronze

A copper alloy containing beryllium and small amounts of cobalt, nickel and/or iron, that can be strengthened by heat treatment. Material solution heat treated at high temperature has a soft supersaturated alpha-phase structure, and subsequent precipitation hardening at lower temperature precipitates a finely dispersed beryllium-rich phase in the matrix. In this condition, the alloy exhibits very high strength and hardness combined with fair conductivity. Cold working, performed before precipitation hardening, can further improve strength and hardness. The most commonly used wrought forms are plate, strip, rod and wire.

COMPOSITION (weight %)

Be	1.6–1.9
Co+Ni	0.20–0.60
Co+Ni+Fe	0.20–0.60
Cu	rem.

1 SOME TYPICAL USES

Electrical

Springs, contacts and connectors; circuit-breaker parts; fuse clips; contact pads; plugs for high-frequency connectors.

Mechanical

Springs; pressure-responsive elements, including diaphragms, flexible bellows and tubes of Bourdon pressure gauges; numerous components of industrial and aircraft instruments; non-sparking safety tools; watch and clock parts; crinkle washers; resistance-welding electrodes and ancillary equipment, including flash-welding dies; components for cryogenic equipment; wear-resistant parts, including guides, bushings, bearings and cams; chains and other components for non-magnetic applications.

2 PHYSICAL PROPERTIES

The "solution heat treated" and "precipitation hardened" conditions referred to in this section relate to material with or without cold work. When no specific condition is quoted, the value shown is applicable to material in all conditions of heat treatment and working.

		Metric Units	English Units
2.1	Density at 20 °C *68 °F* (solution heat treated or precipitation hardened)	8.25 g/cm³	0.300 lb/in³
2.2	Melting range	870–990 °C	1 600–1 815 °F
2.3	Coefficient of thermal expansion (linear) at:		
	—246 to 25 °C *—411 to 77 °F*	0.000 013 per °C	0.000 007 per °F
	— 76 to 25 °C *—105 to 77 °F*	0.000 015 ,, ,,	0.000 008 ,, ,,
	20 to 100 °C *68 to 212 °F*	0.000 017 ,, ,,	0.000 009 ,, ,,
	20 to 200 °C *68 to 392 °F*	0.000 017 ,, ,,	0 000 009 ,, ,,
	20 to 300 °C *68 to 572 °F*	0.000 018 ,, ,,	0.000 010 ,, ,,
2.4	Specific heat (thermal capacity) at:		
	20 °C *68 °F*	0.10 cal/g °C	0.10 Btu/lb °F
2.5	Thermal conductivity at:		
	—269 °C *—452 °F* (precipitation hardened)	~0.004 5 cal cm/cm² s °C	~1.1 Btu ft/ft² h °F
	—263 °C *—441 °F* (,, ,,)	~0.012 ,,	~2.8 ,,
	—253 °C *—423 °F* (,, ,,)	~0.026 ,,	~6.2 ,,
	—193 °C *—315 °F* (,, ,,)	~0.089 ,,	~21 ,,
	20 °C *68 °F* (solution heat treated)	~0.20 ,,	~48 ,,
	20 °C *68 °F* (precipitation hardened)	0.26–0.31 ,,	63–75 ,,
	200 °C *392 °F* (,, ,,)	0.32–0.37 ,,	77–90 ,,
2.6	Electrical conductivity (volume) at:		
	20 °C *68 °F* (solution heat treated)	~10 m/ohm mm²	~18 % IACS
	20 °C *68 °F* (precipitation hardened)	13–19 ,,	22–32 ,, ,,
	200 °C *392 °F* (,, ,,)	10–14 ,,	17–24 ,, ,,
2.7	Electrical resistivity (volume) at:		
	20 °C *68 °F* (solution heat treated)	~0.096 ohm mm²/m ~9.6 microhm cm	~58 ohms (circ mil/ft) ~3.8 microhm in
	20 °C *68 °F* (precipitation hardened)	0.078–0.054 ohm mm²/m 7.8–5.4 microhm cm	47–32 ohms (circ mil/ft) 3.1–2.1 microhm in
	200 °C *392 °F* (,, ,,)	0.10–0.072 ohm mm²/m 10–7.2 microhm cm	61–43 ohms (circ mil/ft) 4.0–2.8 microhm in
2.8	Temperature coefficient of electrical resistance at:		
	20 °C *68 °F* (solution heat treated) applicable over range 0 to 100 °C *32 to 212 °F*	~0.001 0 per °C (18% IACS)	~0.000 6 per °F (18% IACS)
	20 °C *68 °F* (precipitation hardened)	0.000 9 ,, ,, (22 ,, ,,)	0.000 5 ,, ,, (22 ,, ,,)
	applicable over range from 0 to 100 °C *32 to 212 °F*	0.001 3 ,, ,, (32 ,, ,,)	0.000 7 ,, ,, (32 ,, ,,)
2.9	Modulus of elasticity (tension) at 20 °C *68 °F*:		
	solution heat treated	12 500 kg/mm²	17 800 000 lb/in²
	precipitation hardened	13 500 kg/mm²	19 200 000 lb/in²
2.10	Modulus of rigidity (torsion) at 20 °C *68 °F*:		
	solution heat treated	4 600 kg/mm²	6 600 000 lb/in²
	precipitation hardened	5 000 kg/mm²	7 100 000 lb/in²

N.B.: The values shown in Section 2, which have been appropriately rounded in view of the composition range involved, are based on selected literature references; the melting range covers the highest liquidus and lowest solidus temperatures over the composition range quoted.

INDEX NUMBERS RELATE TO LITERATURE REFERENCES (see page 8); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

Prepared by
CONSEIL INTERNATIONAL POUR LE DEVELOPPEMENT DU CUIVRE (CIDEC)
100, rue du Rhône - 1204 GENEVE

Distributed by
CENTRE D'INFORMATION CUIVRE, LAITONS, ALLIAGES
67 Boulevard Berthier, F75017 PARIS

DATA SHEET No. C 4
© Cu Be1.7 Co Ni
1972 Edition

3 FABRICATION PROPERTIES

The information given in this table is for general guidance only, since many factors influence fabrication techniques. The values shown are approximate only, since those used in practice are dependent upon form and size of metal, equipment available, techniques adopted and properties required in the material.

For further information on heat treatment and the related properties of this alloy, see General Data Sheet No. 4.

		Metric Units	English Units
3.1	Casting temperature range [(a)]	1 030–1 100 °C	1 885–2 010 °F
3.2	Heat treatment conditions		
3.2.1	Solution heat treatment		
3.2.1.1	Temperature range	740– 800 °C	1 365–1 470 °F
3.2.1.2	Time at temperature	60–15 min.	
3.2.1.3	Type of furnace	Muffle	
3.2.1.4	Cooling	Water quench	
3.2.2	Interstage annealing temperature range	600– 750 °C	1 110–1 380 °F
3.2.3	Precipitation hardening		
3.2.3.1	Temperature range	300– 350 °C	570– 660 °F
3.2.3.2	Time at temperature	3–0.5 h	
3.2.3.3	Type of furnace	Muffle or salt bath	
3.2.3.4	Cooling	Air	
3.3	Hot working temperature range	625– 800 °C	1 155–1 470 °F
3.4	Hot formability	Good	
3.5	Cold formability		
	Solution heat treated	Good	
	Precipitation hardened	Limited	
3.6	Cold reduction		
	Solution heat treated	40% max.	
	Precipitation hardened	10% max.	
3.7	Machinability:	See General Data Sheet No. 2	
	Machinability rating (free-cutting brass = 100)		
	Solution heat treated and cold worked	30%	
	Precipitation hardened	20%	
3.8	Joining methods: [(a)] [(b)]	See General Data Sheet No. 3.3	
	Soldering	Good	
	Brazing	Good	
	Oxy-acetylene welding	Not recommended	
	Carbon-arc welding	Not recommended	
	Gas-shielded arc welding	Good	
	Coated metal-arc welding	Fair	
	Resistance welding: spot	Good	
	seam	Fair	
	butt	Fair	

(a) Adequate fume extraction must be ensured during melting casting and welding to avoid risk of toxicity from beryllium oxide.

(b) These processes, involving the application of heat, are generally restricted to solution-heat-treated material, but soldering must be carried out after precipitation hardening to avoid melting of the joint.

4 NATIONAL SPECIFICATIONS FOR MANUFACTURED FORMS

and ISO Recommendation

Country	Designation of Standards	Designation of Material in Standards	Specification for Chemical Composition [a]	Plate Sheet Strip	Rod	Wire	Tube	Sections/Shapes	Forgings
Australia	SAA	—	—	—	—	—	—	—	—
Belgium	NBN	—	—	—	—	—	—	—	—
Canada	CSA	—	—	—	—	—	—	—	—
Chile	NCh (INDITECNOR)	Cu Be1.7 Co Ni	252 of. 68	—	—	—	259 of. 70	—	—
France	NF	—	—	—	—	—	—	—	—
Germany	DIN	CuBe1.7	17 666	1780 17 670	17 672	17 677 17 682	—	—	—
India	IS	—	—	—	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	BeCu P1 BeCu R1	—	H 3801	—	—	—	—	—
Netherlands	N or NEN [b]	Cu-Be1.7 Co Ni	NEN 6030	NEN 6033	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	—	—	—	—	—	—	—	—
Sweden	SIS	—	—	—	—	—	—	—	—
Switzerland	VSM	—	—	—	—	—	—	—	—
United Kingdom	BS	CB101 A4/2	—	2870	4577	2873	3127	—	4577
United States [c]	ASTM	No. 170	—	B194	B196	—	—	—	—
International Organisation for Standardization	ISO	Cu Be1.7 Co Ni	R 1187	—	—	—	—	—	—

(a) Applicable when the chemical composition is not given in the specifications for wrought forms.
(b) Older specifications bear prefix N; for new specifications the NEN prefix is used.
(c) In the United States, flat bar is covered under the Plate-Sheet-Strip column.

5 MECHANICAL PROPERTIES

5.1 Mechanical properties at room temperature

Tensile properties	see tables 5.1.1/2/3.1/3.2
Hardness	,, ,, 5.1.1/2/3.1/3.2
Shear strength	,, ,, 5.1.1/2/3.1/3.2
Modulus of elasticity (tension)	see 2.9
Modulus of rigidity (torsion)	,, 2.10

5.2 Mechanical properties at low temperature

Tensile properties	see tables 5.2.1.1/2
Impact properties	,, ,, 5.2.1.1/2

5.3 Mechanical properties at elevated temperature

Short-time tensile properties	no data
Creep properties	,, ,,

5.4 Fatigue properties

Fatigue strength at room temperature	see tables 5.4.1.1/2

5.1 MECHANICAL PROPERTIES AT ROOM TEMPERATURE[a]

5.1.1 Typical Tensile Properties and Hardness Values—Metric Units

This table is representative of practice in many European countries. For British and American practices, see tables 5.1.2 and 5.1.3, respectively.

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.

For a given temper, individual elongation values may show some variation above or below the typical values indicated.

The mechanical properties of this alloy are largely dependent upon heat treatment conditions. For further information, see General Data Sheet No. 4

Form	Temper	Tensile Strength kg/mm²	Proof Stress 0.2% offset kg/mm²	Elongation		Hardness		Shear Strength kg/mm²	Typical Size Related to Properties Shown[b]
				%	gauge length	Brinell	Vickers		
Plate Strip	Solution Heat Treated	48	20	50	$5.65\sqrt{S_o}$	95	100	—	0.2–5 mm thick
	Solution Heat Treated and Cold Worked to Typical Tempers	52	37	30	$5.65\sqrt{S_o}$	135	140	—	0.2–5 mm thick
		58	48	20	50 mm	160	170	40	0.2–3 mm thick
		63	53	15	50 mm	185	195	43	"
		70	60	6	50 mm	210	220	—	0.2–1 mm thick
		75	65	4	50 mm	220	230	49	"
	Precipitation Hardened after Solution Heat Treatment	116	100	7	$5.65\sqrt{S_o}$	340	355	60	0.2–5 mm thick
		118	100	3	50 mm	350	365	61	0.2–3 mm thick
	Precipitation Hardened after Cold Working to Typical Tempers	124	108	2	50 mm	360	380	60	0.2–3 mm thick
		128	115	1	50 mm	375	395	—	0.2–1 mm thick
		133	120	—	—	385	405	—	"
Strip	Mill Hardened to Typical Tempers	73	60	20	50 mm	240	250	35	0.2–5 mm thick
		80	67	17	50 mm	255	270	41	0.2–3 mm thick
		89	76	15	50 mm	280	295	46	"
		100	87	11	50 mm	310	325	50	0.2–1 mm thick
		118	105	6	50 mm	335	350	54	"
Rod[c]	Solution Heat Treated	47	20	45	$5.65\sqrt{S_o}$	95	100	—	2–50 mm diam. or equivalent area
	Solution Heat Treated and Cold Worked to Typical Tempers	55	38	30	$5.65\sqrt{S_o}$	135	140	38	25–50 mm diam. or equivalent area
		65	55	15	$5.65\sqrt{S_o}$	185	195	—	5 to 25 mm diam. or equivalent area
	Precipitation Hardened after Solution Heat Treatment	116	100	6	$5.65\sqrt{S_o}$	340	355	60	2–50 mm diam. or equivalent area
	Precipitation Hardened after Cold Working to Typical Tempers	118	100	3	$5.65\sqrt{S_o}$	335	350	61	25–50 mm diam. or equivalent area
		125	110	2	$5.65\sqrt{S_o}$	360	380	64	up to 25 mm diam. or equivalent area
Wire	Solution Heat Treated	46	22	40	100 mm	—	—	—	—
	Solution Heat Treated and Cold Drawn to Typical Tempers	72	63	5	100 mm	—	—	40	2–5 mm diam.
		85	76	3	100 mm	—	—	42	1–2 mm diam.
		100	88	2	100 mm	—	—	55	up to 1 mm diam.
	Precipitation Hardened after Solution Heat Treatment	116	100	3	100 mm	—	—	60	—
	Precipitation Hardened after Cold Drawing to Typical Tempers	125	110	—	—	—	—	64	2–3 mm diam.
		129	115	—	—	—	—	—	1–2 mm diam.
		135	122	—	—	—	—	—	up to 1 mm diam.

(a) It will be noted that tables 5.1.1, 5.1.2 and 5.1.3, giving typical tensile properties and hardness values in Metric, SI and English, and American units respectively, are not directly comparable. This is because the properties quoted reflect to some extent the metal working techniques, specification practices, and testing procedures in the countries concerned, and in view of the different sizes of products referred to in these tables. Individual manufacturers of semi-fabricated products, can, however, normally meet the requirements of any national standard.

(b) It is possible to obtain sizes outside the ranges given in this column, but information on their mechanical properties should be obtained from the metal manufacturers.

(c) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

5.1.2 Typical Tensile Properties and Hardness Values—SI and English Units

This table is based on British practice. For other European and American practices, see tables 5.1.1 and 5.1.3, respectively.

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.

For a given temper, individual elongation values may show some variation above or below the typical values indicated.

The mechanical properties of this alloy are largely dependent upon heat treatment conditions. For further information, see General Data Sheet No. 4.

Form	Temper [a]		Tensile Strength		Proof Stress 0.1% Offset		Elongation		Vickers Hardness	Shear Strength		Typical Size Related to Properties Shown[b]
			hbar	ton/in²	hbar	ton/in²	%	gauge length		hbar	ton/in²	
Strip	Solution Heat Treated	W	48	31	19	12	45	50 mm (2 in.)	105	—	—	0.15–4 mm (0.006–0.16 in.) thick
Strip	Solution Heat Treated and Cold Worked to Typical Tempers	W(¼H)	57	37	42	27	22	50 mm (2 in.)	175	37	24	0.15–3 mm (0.006–0.12 in.) thick
		W(½H)	63	41	49	32	15	50 mm (2 in.)	200	42	27	"
		W(H)	74	48	60	39	5	50 mm (2 in.)	230	48	31	0.15–1 mm (0.006–0.04 in.) thick
Strip	Precipitation Hardened after Solution Heat Treatment	WP	116	75	99	64	5	50 mm (2 in.)	355	57	37	0.15–4 mm (0.006–0.16 in.) thick
Strip	Precipitation Hardened after Cold Working to Typical Tempers [e]	W(¼H)P	119	77	102	66	4	50 mm (2 in.)	365	59	39	0.15–3 mm (0.006–0.12 in.) thick
		W(½H)P	124	80	107	69	3	50 mm (2 in.)	375	62	40	"
		W(H)P	131	85	114	74	2	50 mm (2 in.)	390	65	42	0.15–1 mm (0.006–0.04 in.) thick
Strip	'Mill Hardened' to Typical Tempers	(d)	71	46	56	36	20	50 mm (2 in.)	225	32	21	0.15–0.75 mm (0.006–0.03 in.) thick
			79	51	63	41	17	50 mm (2 in.)	250	36	23	"
			88	57	73	47	15	50 mm (2 in.)	295	40	26	"
			97	63	82	53	11	50 mm (2 in.)	330	45	29	"
			114	74	96	62	6	50 mm (2 in.)	360	51	33	"
			121	78	102	66	3	50 mm (2 in.)	380	54	35	"
Rod [c]	Solution Heat Treated	(d)	46	30	19	12	45	$5.65\sqrt{S_0}$	100	—	—	6–25 mm (0.25–1 in.) diam. or equivalent area
Rod [c]	Solution Heat Treated and Cold Drawn to Typical Temper	(d)	63	41	49	32	15	$5.65\sqrt{S_0}$	190	40	26	6–25 mm (0.25–1 in.) diam. or equivalent area
Rod [c]	Precipitation Hardened after Solution Heat Treatment	(d)	116	75	99	64	5	$5.65\sqrt{S_0}$	350	57	37	6–25 mm (0.25–1 in.) diam. or equivalent area
Rod [c]	Precipitation Hardened after Cold Drawing to Typical Temper [e]	(d)	124	80	107	69	3	$5.65\sqrt{S_0}$	370	62	40	6–25 mm (0.25–1 in.) diam. or equivalent area

(continued overleaf)

Table 5.1.2 continued

Form	Temper [a]		Tensile Strength		Proof Stress 0.1% Offset		Elongation		Vickers Hardness	Shear Strength		Typical Size Related to Properties Shown[b]
			hbar	ton/in²	hbar	ton/in²	%	gauge length		hbar	ton/in²	
Wire	Solution Heat Treated	W	46	30	—	—	40	100 mm (4 in.)	—	—	—	0.5–3 mm (0.02–0.125 in.) diam.
	Solution Heat Treated and Cold Drawn to Typical Temper	W(H)	77	50	—	—	<5	100 mm (4 in.)	—	39	25	0.5–3 mm (0.02–0.125 in.) diam.
	Precipitation Hardened after Solution Heat Treatment	WP	116	75	—	—	<5	100 mm (4 in.)	—	63	41	0.5–3 mm (0.02–0.125 in.) diam.
	Precipitation Hardened after Cold Drawing to Typical Temper [e]	W(H)P	131	85	—	—	<5	100 mm (4 in.)	—	65	42	0.5–3 mm (0.02–0.125 in.) diam.
	'Pre-tempered' to Typical Tempers	[d]	108	70	—	—	<5	100 mm (4 in.)	—	—	—	0.2–2 mm (0.008–0.08 in.) diam.
			124	80	—	—	<5	100 mm (4 in.)	—	—	—	,,
Forgings [c]	Solution Heat Treated	[d]	46	30	19	12	45	$5.65\sqrt{S_o}$	100	—	—	—
	Precipitation Hardened after Solution Heat Treatment	[d]	116	75	99	64	4	$5.65\sqrt{S_o}$	375	59	38	—

[a] The recognised temper designations used in the relevant British Standards are also given.
[b] It is possible to obtain sizes outside the ranges given in this column, but information on their mechanical properties should be obtained from the metal manufacturers.
[c] The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.
[d] Tempers not included in current British Standards.
[e] Solution heat treated, cold worked and finally precipitation hardened.

N.B.: Other wrought forms (tape, foil, Bourdon tube, etc.) are also available by arrangement with the manufacturers, who should be consulted concerning the mechanical properties of these products.

5.1.3 Typical Tensile Properties and Hardness Values—American Units

This table is based on American practice and the temper designations shown are those referred to in ASTM and other American Standards. For British and other European countries' practices, see tables 5.1.2 and 5.1.1, respectively.

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.

For a given temper, individual elongation values may show variation above or below the typical values indicated.

The mechanical properties of this alloy are largely dependent upon heat treatment conditions. For further information, see General Data Sheet No. 4.

5.1.3.1 Solution-Heat-Treated Material

Form	Temper	Tensile Strength psi	Yield Strength 0.5% extension under load psi	Elongation		Rockwell Hardness			Shear Strength psi	Typical Size Related to Properties Shown [a]
				%	gauge length	G	B	30 T		
Flat Products (Plate, Strip, Bar and Flat Wire)	Solution Heat Treated	66 000	33 000	50	2 in.	10	55	53	48 000	0.032 in. thick
		63 000	25 000	55	2 in.	3	50	50	45 000	0.250 in. thick
	Solution Heat Treated and Cold Worked									
	Quarter Hard	76 000	66 000	30	2 in.	53	83	73	56 000	0.032 in. thick
	Half Hard	88 000	74 000	15	2 in.	68	91	79	65 000	,,
	Hard	106 000	98 000	5	2 in.	78	97	82	75 000	,,
	Half Hard	85 000	75 000	20	2 in.	63	88	75	64 000	0.250 in. thick
	Hard	100 000	92 000	10	2 in.	71	93	78	72 000	,,
Rod [b]	Solution Heat Treated	63 000	27 000	55	2 in.	3	50	50	45 000	0.250 in. diam.
	Solution Heat Treated and Cold Worked									
	Half Hard	85 000	78 000	20	2 in.	63	88	75	64 000	0.250 in. diam.
	Hard	100 000	94 000	10	2 in.	71	93	73	72 000	,,
Wire	Solution Heat Treated	70 000	35 000	40	10 in.	—	—	—	—	0.080 in. diam.
	Solution Heat Treated and Cold Worked									
	Hard Drawn	130 000	110 000	3	10 in.	—	—	—	—	0.080 in. diam.

(continued on opposite page)

5.1.3.2 Precipitation-Hardened Material

Form	Temper	Tensile Strength psi	Yield Strength 0.5% extension under load psi	Elongation %	Elongation gauge length	Rockwell Hardness C	Rockwell Hardness 30 N	Shear Strength psi	Typical Size Related to Properties Shown [a]
Flat Products (Plate, Strip, Bar and Flat Wire)	Precipitation Hardened	167 000	132 000	10	2 in.	34	60	110 000	0.032 in. thick
		165 000	130 000	12	2 in.	33	53	108 000	0.250 in. thick
	Precipitation Hardened after Cold Working								
	Quarter Hard	173 000	146 000	10	2 in.	36	60	114 000	0.032 in. thick
	Half Hard	174 000	152 000	10	2 in.	37	60	115 000	"
	Hard	179 000	162 000	6	2 in.	38	60	117 000	"
	Half Hard	170 000	147 000	10	2 in.	35	58	112 000	0.250 in. thick
	Hard	175 000	158 000	6	2 in.	37	58	115 000	"
Rod [b]	Precipitation Hardened	165 000	132 000	12	2 in.	33	53	108 000	0.250 in. diam.
	Precipitation Hardened after Cold Working								
	Half Hard	170 000	150 000	10	2 in.	35	58	112 000	0.250 in. diam.
	Hard	175 000	160 000	6	2 in.	37	58	115 000	"
Wire	Precipitation Hardened	170 000	155 000	5	10 in.	—	—	—	0.080 in. diam.
	Precipitation Hardened after Cold Working								
	Hard Drawn	200 000	185 000	2	10 in.	—	—	—	0.080 in. diam.

(a) It is possible to obtain sizes different from those given in this column, but information on their mechanical properties should be obtained from the metal manufacturers.
(b) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

5.2 MECHANICAL PROPERTIES AT LOW TEMPERATURE

5.2.1 Tensile Properties—Impact Properties

5.2.1.1 Solution-Heat-Treated Material

Form	Temper	Testing Temperature °C	Testing Temperature °F	Tensile Strength kg/mm²	Tensile Strength ton/in²	Tensile Strength psi	Proof Stress 0.2% offset kg/mm²	Elongation %	Elongation gauge length	Reduction of Area %	Impact Strength kg m/cm²	Impact Strength ft lb
Rod [1] [d] 14 mm diam. 0.560 in. diam.	Solution Heat Treated	27	80	51.5	33	**73 400**	24.0 [a]	**52**	1 in.	**74**	28.5 [b]	**103** [b]
		—59	—75	52	33	**74 300**	27.0 [a]	**55**	1 in.	**75**	26.3 [b]	**95** [b]
		—129	—200	59.5	37.5	**84 300**	32.0 [a]	**51**	1 in.	**75**	23.0 [b]	**83** [b]
		—184	—300	69	43.5	**97 800**	40.2 [a]	**50**	1 in.	**68**	20.2 [b]	**73** [b]
	Solution Heat Treated and Cold Worked	27	80	72.5	46	**103 000**	68.9 [a]	**16**	1 in.	**57**	8.3 [b]	**30** [b]
		—59	—75	76.5	48.5	**109 000**	68.5 [a]	**20**	1 in.	—	8.3 [b]	**30** [b]
		—129	—200	82.5	52	**117 000**	73.1 [a]	**21**	1 in.	**49**	8.6 [b]	**31** [b]
		—184	—300	81	51.5	**115 000**	77.3 [a]	**20**	1 in.	**50**	7.5 [b]	**27** [b]
Rod [2] [e] 19 mm diam. 0.75 in. diam.	Solution Heat Treated	20	68	49	31	**69 900**	19.3 [a]	**62.6**	$4.52\sqrt{S_o}$	**79.6**	28.3 [c]	**102.5** [c]
		—78	—108	52.5	33.5	**74 900**	24.4 [a]	**69.0**	$4.52\sqrt{S_o}$	**79.0**	27.2 [c]	**98.5** [c]
		—197	—323	69.5	44	**99 000**	34.7 [a]	**69.8**	$4.52\sqrt{S_o}$	**72.8**	24.0 [c]	**86.5** [c]
		—253	—423	82.5	52.5	**117 200**	40.9 [a]	**69.0**	$4.52\sqrt{S_o}$	**69.8**	—	—
	Solution Heat Treated and Cold Worked	20	68	71.5	45.5	**101 800**	68.0 [a]	**19.2**	$4.52\sqrt{S_o}$	**68.0**	10.4 [c]	**37.5** [c]
		—78	—108	76	48.5	**108 400**	70.4 [a]	**22.9**	$4.52\sqrt{S_o}$	**69.8**	11.0 [c]	**40.0** [c]
		—197	—323	92.5	59	**131 900**	83.5 [a]	**31.0**	$4.52\sqrt{S_o}$	**66.0**	9.5 [c]	**34.5** [c]
		—253	—423	108	68.5	**153 800**	83.7 [a]	**31.4**	$4.52\sqrt{S_o}$	**60.0**	—	—

5.2.1.2 Precipitation-Hardened Material

Form	Temper	Testing Temperature °C	Testing Temperature °F	Tensile Strength kg/mm²	Tensile Strength ton/in²	Tensile Strength psi	Proof Stress 0.2% offset kg/mm²	Elongation %	Elongation gauge length	Reduction of Area %	Impact Strength [b] kg m/cm²	Impact Strength [b] ft lb
Rod [1] [d] 14 mm diam. 0.560 in. diam.	Precipitation Hardened	27	80	132	83.5	**187 600**	102 [a]	**6**	1 in.	**7**	1.3	**4.8**
		—59	—75	133	84.5	**189 000**	113 [a]	**6.5**	1 in.	**10**	1.5	**5.3**
		—129	—200	138	87.5	**196 000**	115 [a]	**9.5**	1 in.	**13**	1.6	**5.8**
		—184	—300	149	94.5	**212 000**	120 [a]	**9.5**	1 in.	**14**	1.9	**6.8**
	Precipitation Hardened after Cold Working	27	80	136	86.5	**193 500**	119 [a]	**4**	1 in.	**12**	1.4	**5.0**
		—59	—75	138	87.5	**196 000**	126 [a]	**4.5**	1 in.	**13**	1.4	**5.0**
		—129	—200	143.5	91	**204 000**	136 [a]	**4.5**	1 in.	**14**	1.5	**5.5**
		—184	—300	151.5	96	**215 500**	139 [a]	**5.5**	1 in.	**10**	2.0	**7.3**

(a) This value was originally reported in psi; in this table it is given in kg/mm² to 3 significant figures.
(b) Charpy Keyhole-notch specimen; cross-sectional area at the notch 0.5 cm².
(c) Charpy U-notch specimen; cross-sectional area at the notch 0.5 cm².
(d) Alloy containing 1.86% Be
(e) Alloy containing 1.8% Be.

N.B.: —Original values are printed in **bold type**; other values are converted.
—All converted values for impact strength are to be taken as indicative only, the impact energy has been converted from ft lb into kg m/cm² taking into account the actual cross-sectional area at the notch.
—Data not available: Proof stress, 0.1% offset.
Yield strength, 0.5% extension under load.

5.3 MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE

At the date of publication of this sheet, no data relating to this material have been traced. The elevated-temperature mechanical properties of Cu Be1.7 Co Ni would, however, be expected to follow a similar trend to those of Cu Be2 Co Ni, which are detailed in Section 5.3 of data sheet C5.

5.4 FATIGUE PROPERTIES

5.4.1 Fatigue Strength at Room Temperature

5.4.1.1 Solution-Heat-Treated Material

Form	Temper	Number of Cycles × 10^6	Metric Units kg/mm²		English Units ton/in²		American Units psi	
			Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength
Strip [3] 0.8 mm 0.032 in.	Solution Heat Treated 11%	100	53.5 [f] 55 [g]	25.5 [a] 24.5 [a]	34 [f] 35 [g]	16.5 [a] 15.5 [a]	**75 800** [f] **78 000** [g]	**36 500** [a] **35 000** [a]
	and Cold Worked 21%	100	62 [f] 64 [g]	27 [a] 24.5 [a]	39 [f] 40.5 [g]	17 [a] 15.5 [a]	**87 900** [f] **90 800** [g]	**38 500** [a] **35 000** [a]
	37%	100	74 [f] 76 [g]	27.5 [a] 25.5 [a]	47 [f] 48 [g]	17.5 [a] 16.5 [a]	**105 000** [f] **108 000** [g]	**39 000** [a] **36 500** [a]

5.4.1.2 Precipitation-Hardened Material

Form	Temper	Number of Cycles × 10^6	Metric Units kg/mm²		English Units ton/in²		American Units psi	
			Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength
Strip [3] 0.8 mm 0.032 in.	Precipitation Hardened [d]	100	117.5 [f] 128 [g]	24.5 [a] 25.5 [a]	74.5 [f] 81 [g]	15.5 [a] 16 [a]	**167 100** [f] **181 800** [g]	**35 000** [a] **36 000** [a]
	Precipitation Hardened [e] 11%	100	121.5 [f] 129 [g]	29.5 [a] 28 [a]	77.5 [f] 82 [g]	19 [a] 18 [a]	**173 100** [f] **183 800** [g]	**42 300** [a] **40 000** [a]
	after Cold Working 21%	100	122.5 [f] 133.5 [g]	29.5 [a] 31 [a]	77.5 [f] 85 [g]	18.5 [a] 19.5 [a]	**174 000** [f] **190 000** [g]	**42 000** [a] **44 000** [a]
	37%	100	126 [f] 138.5 [g]	34 [a] 30.5 [a]	80 [f] 88 [g]	21.5 [a] 19.5 [a]	**179 100** [f] **196 700** [g]	**48 500** [a] **43 500** [a]
Wire [4]	Precipitation Hardened after Cold Working 50%	100	**120** **120**	**30** [b] **10** [c]	76 76	19 [b] 6.5 [c]	170 500 170 500	42 500 [b] 14 00 [c]

(a) Reversed-bending test.
(b) Bending-fatigue test.
(c) Rotating-fatigue test.
(d) 3h at 600 °F (*316 °C*).
(e) 2h at 600 °F (*316 °C*).
(f) Alloy containing 1.70% Be.
(g) Alloy containing 1.81% Be.

N.B.:—Original values are printed in **bold type**; other values are converted.
Further data can be obtained from ref. (3).

REFERENCES

MECHANICAL PROPERTIES (SECTION 5)

(1) Richards, J. T. and Brick, R. M. Mechanical Properties of Beryllium Copper at Subzero Temperatures. Trans. AIME (Inst. Met. Divn.), Vol. 200 (1954), pp. 574-580.

(2) Warren, K. A. and Reed, R. P. Tensile and Impact Properties of Selected Materials from 20 to 300 °K. U.S. Dept. Commerce, Nat. Bureau of Standards Monograph 63 (1963).

(3) Gohn, G. R., Herbert, G. J. and Kuhn, J. B. The Mechanical Properties of Copper-Beryllium Alloy Strip. ASTM Spec. Tech. Pub. No. 367 (1964), 114 pp.

(4) Data sheet from Vacuum – Schmelze, Hanau, Germany.